

## Creativity Training in Problem Solving: A Model of Creativity in Mathematics Teacher Education

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### Abstract

*Background:* The goal of the pedagogical content course is to teach how to make mathematics education better through the use of different teaching methods, and techniques. By learning the different teaching methods, future teachers will be able to apply their learning into the teaching.

*Aims:* The aim of this exploratory study is to note and discuss some of the diversified views in the perspectives of the prospective mathematics teachers on improving creative thinking in problem solving.

*Sample:* 43 prospective secondary mathematics teachers participated in the study.

*Method:* All the participants were observed and interviewed during the eleven-week of that academic year. Data were recorded and transcribed.

*Results:* The results related to prospective mathematics teachers' views on how to improve creative thinking, and to provide an analysis on their perception of creativity in problem solving were found. The pedagogical knowledge of mathematics content course should be reconsidered in how to provide subject matter knowledge, and opportunities to teach creative problem solving techniques. This will contribute to the goal of improving creativity in problem solving in mathematics education. In brief, creative training can really enhance creativity.

*Conclusion:* Authors' experiences indicated that the most effective method is to provide a relevant training. Teacher training should be redesign according to creative problem teaching techniques. These include the use of creative problem solving to allow future teachers a chance to have experience and training. The factors of divergent thinking determined were special characteristics, types of thinking, supporting creativity, factors affecting creativity, and the ways to improve creativity.

*Keywords:* Creative training, divergent thinking, problem solving, teacher training

### 解決問題的創意訓練：一個數學教師教育的創意模型

#### 摘要

*背景：*數學教學法科目的目標，是通過不同的教學方法和技術，在數學教育方面裝備其學員，使未來數學老師能學會怎樣應用所學習的去教學。

*目的：*這項探索性研究的目標，注重改進準數學老師去透視創造性思維，在解決問題方面多角度的看法。

*調查對象：*43 位準數學老師參加了這研究。

*調查方法：*這研究在那學年的十一個星期間觀察和採訪了所有參加者，記載和輯錄了有關資料。

*調查結果：*找到了準數學老師關於怎樣改進創造性思維和分析創意解決問題的概念。應該反思教授數學科的方法，以便能提供本科的內容和教創意解決問題技巧的機會。這對改進數學教育中創意解決問題的目標有貢獻。簡而言之，創意的訓練可真正地提高創意。

*總結：*作者的經驗表明，最有效的方法是提供相關的訓練。師範訓練應該是根據創意的問題教授技巧去再設計，這包括使用創意解決問題給未來老師有機會去經驗和訓練。發散性思維的因素有：特別特徵、思維類型、創意的支援、影響創意的因素、和改進創意的的方法。

*關鍵詞：*創意訓練，發散性思維，解決問題，師範訓練

## Introduction

The perception of the prospective mathematics teacher on the notion of creativity is an interesting and important issue in mathematics education. The study is also important to educate prospective mathematics teachers the creative thinking in problem solving during their teacher training. Creativity plays an important role in students' academic achievement (Onda, 1994). Creative thinking can be improved with creativity, and with the use of creative problem solving techniques (Puccio and Murdock, 2001), and open-ended questions (Silver, 1993). Additionally, Meissner (1999) says that students should be asked challenging question to improve creativity in mathematics. It is commonly believed that divergent thinking exercises should be done in the training. A desired teaching situation can be reached through problem solving and brainstorming being used in conjunction with each other, and to encourage the students to produce more answers, the mathematics teacher needs to assume the role leader for these exercises. Real life questions should be presented to students and problems should include contradictory situations. This gives them an opportunity to use their creative thinking (Ediger, 2000). According to Fisher (1995), real life problems, as they were developed to consider real life, need to be open-ended. However, currently, the problems presented to students are not real life problems. Instead, students are mostly asked close-ended questions, which direct them to one answer only, and this is what causes the conflict. The use of standard operations to solve closed-ended questions results in the information of clinches and algorithms, and causes mental barriers (Haylock, 1987).

There is not a single description of creativity, and to define it is difficult to design. However, there are some descriptions

of creativity that focus on this study with new and different types of thinking, and these have contributed to determination of what it takes to be creative. In the present study, creativity defined as an *idea or product should be new, original and appropriate*. Creativity is a thinking process that results in new, unusual, and insightful solutions to a given problem that can branch from any difficulty, by thinking divergently and looking at problem solving using new perspectives. The present research combined creativity with six adjectives, *novelty, originality idea, creative product, creativity process, creative person, and creative environment*. Starko (2004) mentioned first two of them while Fisher (1995, p.31) mentioned last four of them.

## LITERATURE REVIEW

According to the related literature, creativity in problem solving related to thinking patterns such as creative, divergent, reflective and convergent thinking. According to Feldhusen (1995, p.31), creative thinking is the process of modifying ideas from existing knowledge, along with the ability to form, or to bring forth, a new thought by using intellectual imagination. Divergent thinking develops and broadens out thinking process while thinking divergently entails starting with a specific problem or idea and generating various perspectives on it. The purpose of divergent thinking is to ignore constraints, and to entertain all different kinds of possibilities. On the other hand, there is a parallelism between the uses of divergent and creative thinking together by teachers in mathematics lessons. Haylock (1987, 1997) notes that having an acceptance of teachers receiving improved creativity in problem solving by getting rid of obsessions, and through divergent thinking. Teachers who make statements supporting their ability to get rid themselves of obsessions were more suitable to Ediger's (2000) statement of a creative

mathematics teacher. Reflective thinking is the child of careful, efficient and consistent thinking that supports an idea, or knowledge, and the reaching of the goals it aims to achieve (Dewey, 1991). Rodgers (2002) perceives reflective thinking as the process of carrying one's own experience into meaning-formation, and the relation and connection of bringing a deep understanding into other experiences and ideas. Components of reflective thinking are attitudes, process, content and depth (Lee, 2000). Thinking patterns have important role of presenting creativity. Teachers' effect on students' attitudes towards creativity helps the students to develop positive attitudes towards mathematics. Education focuses on judging ideas, and those were judged without being considered well enough or there can be prejudices towards them. According to Sternberg (1996), the development of creativity is time-consuming and quite normal that the techniques being applied take time to improve and comprehend. A prejudiced teacher prefers to judge rather than to generalize ideas and to have little or too much self-confidence stands as a barrier to the development of their creativity. It can be stated that those individuals cannot overcome the mental, comprehensive, and emotional barriers. Parnes (1978) puts forth that prospective teachers indicated that they developed their self-confidence and freedom by participating in the creativity training. Scott et al. (2004) implicates that the training aimed at developing creativity provided self-confidence to the participants. Additionally, Haylock (1987) determined that teachers, who express their development of confidence and opinions to use different ways in problem solving, are an indicator of their getting rid of obsessions. It is obvious that teachers' attitudes, beliefs, and classroom activities have an important effect on the development of students' creativity (Cropley, 1994; Fleith, 2000). Therefore, it is a necessity for the application to have positive attitudes toward those kinds of activities

(Sternberg, 1996). First of all, in order to develop creativity, teachers should be both open-minded (Barak et.al, 2002) and have new thoughts (Evans, 1991). This can be achieved by not being biased about the programs they apply for their biases may prevent creativity. Creative individuals develop a strong self-confidence (Sternberg, 1988; Brolin, 1992).

A perception is a barrier of learning. Additionally, some barriers such as family and relatives, the educational system, and the organizational environment are external. The mental barriers, named inner barriers, were formed by our confrontation of outer or physical effects. The key to improving creativity is to remove these barriers and to prevent these barriers from forming. Every person has barriers, but the degree and number of these barriers changes from one to another. Adams (1986) connected the barriers to creativity with four subtitles: perception, emotional, cultural, environmental, and mental. Perceptual barriers restrict the information gathering needed to understand the problem, or the inability to identify the problem itself. Perceptual barriers result from the fact that learner perception is not always right (Vidal, 2004). Haylock (1987) divides into two fixation categories. One is algorithmic fixation (obsession), and the other is a real life obsession. According to Finke and et al. (1996, p.150):

"Fixation is a very general phenomenon and occurs in a wide variety of cognitive domains, including output interference in retrieval (Rundus, 1973), the tip-of-the-tongue phenomenon (Brown and McNeill, 1966), the use of algorithms in problem solving (Luchins and Luchis, 1959), and creative idea generation (Smith, Ward, and Schumcher 1991)."

The educational system in terms of the attitudes of teachers towards the students and their educational philosophy may become a barrier for creativity. Especially, at primary school, as education is regarded as students' feedback that has been learnt to the teacher in the same the way it is taught to them. From the 1<sup>st</sup> to the 8<sup>th</sup> grade the students have been discouraged from being creative, and from using their imagination. Using this process of educating, the way of thinking for the students will end in them either quitting or forgetting what they were taught (Whitson, 1994, p.2-3). Educational institutions force individuals to put their ideas into a form, to restrict them, and make them solid. Therefore, in the end, their thoughts become like a concrete building at which is to change. Thus, students end their education without knowing how to take risks, or how to think for themselves (Gorhom et al., 1992)

Evans (1991) defined emotional barriers as they restrict the independence to change and research ideas. They prevent the communication of ideas; also they are psychological barriers that prevent novelty. Mental and comprehensive barriers needed keep up because they involve in being reluctant to use new approaches, having a lack of mental background, and choosing inefficient techniques. The people with mental and comprehensive barriers deal with the same problems with the same tools and approaches for years, and usually are closed-minded to new ideas, and are very quick to criticize new proposals. For example, while solving a problem they prefer to use wrong language, they use the same problem solving techniques again and again, and their lack of accurate knowledge is a direct result of having these mental and comprehensive barriers (Evans, 1991; Vidal, 2004). Another barrier is time. Individual creativities take time to develop. In learning to make choices among the alternatives, there is an incubation period that does not allow time

for thinking and therefore, taking time for these events to happen may become a barrier for teachers to becoming creative (Sternberg, 2003). Motivation is a source of creativity (De Bono, 1993). Amabile (1983, p.99-100) emphasized that in fully formed creative environments, having inner and outer motivation may result in creativity, while inner and outer motivation may harm creativity in a creative environment. Motivation plays a crucial role in improving creativity, and there are various ways to improve creativity. Apart from barriers, possessing habits are also a barrier. Habits are necessary for us to carry out both personal and professional tasks without using unnecessary effort. The development habits are adequate in education and experiences in life. In almost every situation, daily life is managed through our habits and these habits are behaviors that are rooted in the brain, and therefore, they imprison us to look at things and events in traditional ways. When they prevent one from being creative, one falls into an unchanging pattern. Although habits can be helpful to solve a problem that has been experienced before, it can, in the case of a new problem, cause problems to be looked at with restricted thinking and cause one to attempt to apply an inappropriate solution stemming from prior use. With habits, thoughts become unchanged. This is called functional barrier obsession and stability in problem solving. Habits, such as seeking a quantitative solution in habitual ways, hinder creativity and creativity in problem solving. There is a need to recognize these habits before being able to quit using them and thus becoming more creative (Evans, 1991, p.48-49)

Past creativity studies in mathematics education did not concentrated on prejudice, negative attitudes from prejudice, anticipation-goal, change in thinking, difficulties in-competencies, absence, techniques of instructions, and permanence in creativity education and application in

creativity in problem solving. This is a qualitative study, which gathers all the factors affecting creativity and a unique study which adopts different teaching approaches.

### Aim

The aim of this exploratory study is to note and discuss some of the diversified views from the perspectives of the prospective mathematics teachers on improving the creative thinking in problem solving.

**Study questions:** The following six questions were asked:

1. What do you think about creative training?
2. How do you assess yourself before, during and after training?
3. At the end of the training, are there any development and changes in problem solving techniques? If so, why? If not, why?
4. How did you think about designing and applying of creative techniques in problem solving? What did you meet in terms of obstacles or barriers? If so, why?
5. Did you think any relationship between the training and mathematics teaching? If so, why?
6. Do you think any obstacles to learning problem solving? If so, how do you improve creativity in problem solving?

### METHOD

#### *Participants*

43 prospective secondary mathematics teachers participated in the study at Necatibey Educational Faculty of Balıkesir University in Turkey. The prospective secondary mathematics teacher training has 5-year study programs. The age

range of the participants was between 19-24 years. 11 groups were formed voluntarily.

### TOOLS

#### **Creativity Training**

Secondary school mathematics teachers usually prefer teaching with of traditional teaching techniques in Turkish secondary schools. They usually prefer to use problem solving through algorithmic approaches, rather than using new teaching methods. The reason for this is that they believe that practicing examples in this way is the best preparation for the university entrance examination (OSS). Additionally, the secondary mathematics school curriculum is perceived as a real barrier to being able to put an emphasis on new learning techniques. The content knowledge courses of prospective mathematics teachers were three hours a week. Before training, an information study was conducted with the prospective mathematics teachers. Twenty-two different techniques were also introduced to them. 22 techniques of creativity are: 1.*Brainstorming* (Starko, 2004), 2. *Creative Pause*, 3. *Challenge*, 4. *Focus*, 5. *Alternatives*, 6. *Six Thinking Hats* (De Bono, 1993), 7. *Movement*, 8. *Creative Exchange Technique*, 9. *Nominal Group*, 10. *Idea Writing*, 11. *Delphi* (Moore, 1994), 12. *Upside Turning*, 13. *Matrix* (Michalko, 1991), 14. *Simultion* (Dacey, 1989), 15. *Directing Toward The Goal*, 16. *5W 1H* (Van Gundy, 1988), 17. *Re-disgning*, 18. *Gathering*, 19. *Classification*, 20. *Question Production*, 21. *Guessing and Investigating Reasons*, and 22. *Imagination* (Rıza, 2001) used. Also, Meissner (1999), Livne et.al (1999), and Imai (2000)'s activities that include questions containing creative and divergent thinking in problem solving were used in the study. This study, a part of an on-going research project, focuses on teachers' view on creativity training.

### Activity details

Programme for creativity training was formed in sections namely before activities and creative activities. Activity details were given in Table 1.

**Table 1. Programme for creativity training**

Before Activities	Weeks	Researchers role	Participants role
Seminar on creativity	1 <sup>st</sup> week	Presenter, leader	Researcher, active participant
Seminar on creativity techniques	2 <sup>nd</sup> week		
Seminar on creativity problem solving techniques and eleven cooperative-groups established (3-5 participant)	3 <sup>rd</sup> week		
Creativity Activities	Weeks	Researchers role	Participants role
Researchers' sample activities ( <i>Brainstorming; Creative Pause; Challenge; Focus; Six Thinking Hats; Creative Exchange; Nominal Group; Delphi; Matrix; Directing Toward The Goal; 5W1H; Gathering; Question Production; Guessing and Investigating; Imagination</i> )	Between 1 <sup>st</sup> to 5 <sup>th</sup> week	Presenter, leader	Active participant, cooperative practitioner
Groups activities were presented (Open ended task activities) (All the groups were presented at least two creative techniques in mathematical problem solving)	Between 6 <sup>th</sup> to 10 <sup>th</sup> week	Guider, facilitator, observer,	Participant, active presenter, leader, (observer), (cooperative practitioner)
22 techniques used and evaluation was considered	11 <sup>th</sup> week	Presenter, leader, evaluator	Presenter, evaluator, reflector

### PROCEDURE

All the participants were observed and interviewed during the eleven-week teaching period. The Prospective teachers were observed during participation in activities, planning, discussing, and presenting their work, and teaching practice in an eleven-week period. The goal of the training is to teach how to make mathematics education better through the use of different teaching methods, and techniques. By learning the different teaching methods, the prospective teachers will be able to apply their learning to teaching (Gur, 1999). 43 participants were interviewed. The interview questions in the form was constructed and corrected were made. The form consisted of six open-ended questions. All names were anonymous. The interviews were recorded and the each one approximately lasted approximately 25-35 minutes. The entire interviewing process took up 19.5 hours at the end of the semester.

### Data Analysis

Each interview was recorded and transcribed. After that, the data was formed on a data analysis matrix. The researcher's reviewing literature, and re-confirming the data many times, a general coding framework was established (Miles & Huberman, 1994). The whole analysis process was completed in three months. The inter coder correlation of  $r = 0.81$  was computed, thus providing a sufficient relation level. All transcribed extracts were coded by two researchers. Every word, sentence or paragraph was coded according to the coding scheme. Eleven themes were same as the ones presented in the review of literature namely attitude, self-confidence, beliefs, perception, divergent thinking, reflective thinking, creative thinking, fixation, habits, real world problems and educational system. Researchers themes from data were prejudice, negative attitudes from prejudice, anticipation-goal, change in thinking, difficulties in-competencies, absence,

techniques of instructions, permanence in creativity education and application.

**Table 2. The frequencies and percentages of coding of themes and sub-themes**

No	Themes	Sub themes	Fr (M)	Fr (F)	Fr (T)	% (T)
1	<b>Individual Characteristics in Problem Solving</b>	Attitude (Positive)	14	16	30	70
		Attitude (Negative)	3	4	7	16
2		Prejudice	3	2	5	12
3		Negative Attitudes Resulting From Prejudices	4	-	4	9
4		Self-Confidence	12	9	21	49
5		Belief	15	17	32	74
6		Anticipation-Goal	12	14	26	61
7		Change in Thinking	13	8	21	49
8		Perception	8	9	17	40
9	<b>Thinking in Problem Solving</b>	Divergent Thinking	17	18	35	81
10		Reflective Thinking	13	16	29	67
11		Creative Thinking	18	20	38	88
12	<b>Barriers to Creativity in Problem Solving</b>	Fixation-Inflexibility	12	9	21	49
13		Habits	8	11	18	42
14		Difficulties & In-competencies	10	7	17	40
15		Absence	6	7	13	30
16		Educational System	17	14	31	72
17	<b>Improving Creativity in Problem Solving</b>	Method of Instruction	18	19	37	86
18		Relating to Daily Life	15	13	23	54
		Permanence in Creativity Education				
19		Application	10	13	23	54
20		Method of Instruction	14	15	29	67

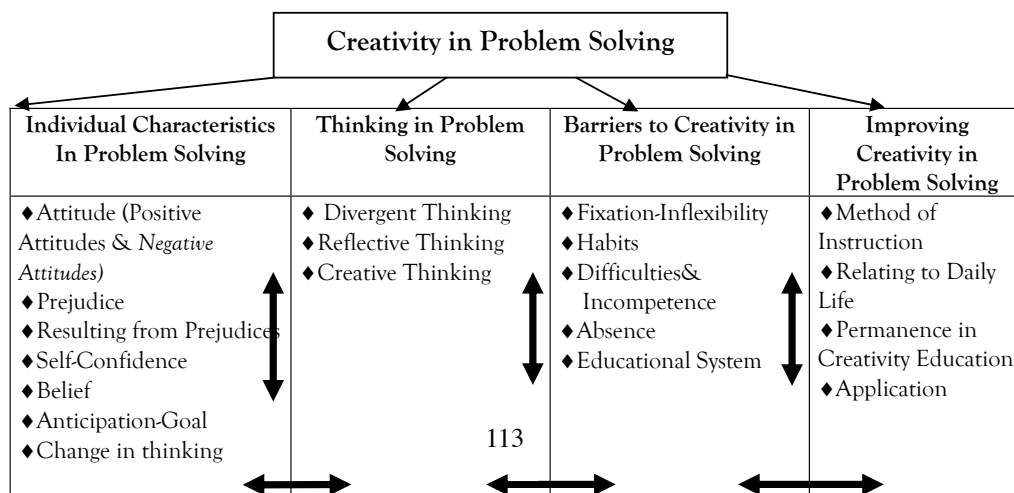
Fr: frequency, %: percentages M: male, F: female, T: total

Finally, the themes and sub-themes were determined according to coding schemes (Table 2). After coding, the main theme was Creativity in Problem Solving, and four sub-themes were determined as *individual characteristics in problem solving*; *thinking in problem solving*; *barriers to creativity in problem solving*; and *improving creativity in problem solving*.

## FINDINGS

Theme and sub-themes were presented below table (Table 3). An arrow shows relations between the themes and sub-themes.

**Table 3: Themes and sub themes**



### **Sub-theme 1: Individual Characteristics In Problem Solving**

The sub-themes were presented the prospective teachers' views. They include attitudes, prejudice, self-confidence, beliefs, anticipation-goal, change in thinking, and perception. These details were given below:

#### **Sub-theme 1.1 Attitude**

The prospective teachers presented both positive and negative attitudes towards the Creativity Training. The creativity training was positive enthusiasm and interest of prospective teachers.

Math is generally regarded as a terrifying and boring subject. The applications of the techniques will arise interest, and prospective teachers who participate will become more keen. Therefore, I'm not sure how much their creativity increases but they will become less terrified of math (Filiz)

The prospective teachers' positive attitudes towards those kinds of activities are an obligation for applications [Sternberg, 1996]. There were also prospective teachers who have negative attitudes. An example was given below.

I only participated in the training because I had to listen to a very boring and unnecessary training (Güven)

First of all, the underlying reason for the negative attitudes is the prospective teacher's the lack of interest in creativity. A prospective teacher' statements towards a prospective teacher of negative attitudes supports this inference;

After the training, I was informed about nearly all techniques, and I have learnt to look at the questions from various points of view. But I don't believe everyone is like me. One look at the ones who don't take creativity seriously and couldn't make a progress is a fact (Nazmi).

The criticisms of these were that their creativity do not improve, and that the techniques applied in math can't improve creativity.

#### **Sub-theme 1.2 Prejudice**

Prospective teachers developed a prejudice toward the training, and the improvement of creativity, along with their own creativity. What follow is some of the prejudice:

I was familiar with creativity but I didn't think of its improvement. I thought creativity was characteristics brought from the birth and could never be improved afterwards (Ahmet).

Prospective teacher presented a negative attitudes resulting from prejudice, and the teachers who behaved in a prejudiced way, later had negative attitudes towards the training.

#### **Sub-theme 1.3 resulting from Prejudices**

The prospective teacher's opinions which bear prejudices, and negative points of view, were presented below:

While applying some techniques, I thought it as unnecessary and a waste of time. This affected me negatively. The others really bored me, and I thought no progress could be achieved in this way. (Prejudice) (Selim)

Among the prospective teachers who presented negative attitudes, the resulting situations such as disinterest in the training, low self-confidence, over-self-confidence, long process of improving creativity, presented a negative attitude toward the training, and their own improvement became apparent.

#### **Sub-theme 1.4 Self-Confidence**

The prospective teachers have, at some time, experienced an increase in self-confidence. The increase of self-confidence is their observation that both their self-confidence and the confidence in using various solution ways in problem solving, has developed fully.



Some supporting examples of this conclusion were listed below:

Learning new techniques have raised my self-confidence. (Increase of self-confidence) (Emrah)

For example, I used to try to find the solution of a geometry question in a conventional way. But now, without concern of finding the solution, I try different ways." (Self-Confidence in Problem Solving) (Selma)

With creative training applied, prospective teachers rid themselves of their fixations by both using their self-confidence and different ways of problem solving.

### **Sub-theme 1.5 Belief**

The prospective teachers have changed some beliefs that they had at the beginning and the end of the training.

The prospective teachers' points of views for belief were as follows:

I believe that these kinds of activities can improve my creativity. (Zeynep)

We learnt to learn and teach in this training and I believe it will be provide good results in the future. (Ömer)

The prospective teachers have changed some of their beliefs at the end of the training.

### **Sub-theme 1.6 Anticipation-Goal**

They indicated that creativity in mathematics education will be efficient in their' attitudes toward the course. A few examples of prospective teachers' opinions regarding anticipation goals were given below:

If appropriate techniques for the class is picked up and applied, I assume their point of views will change. Their ways of thinking of the problem will be quite different. (Canan)

### **Sub-theme 1.7 Change in thinking**

The training helped the participants to change their thinking positively. They have

realized that they couldn't use their prior knowledge efficiently. They noticed the importance of creativity, comprehending the development of creativity, and multi-dimensional thinking.

Thanks to the training applied, we understood the importance of creativity better. (Ömer)

My learning experience on new things about how to enrich education helped me to reach the opinion that I can become a better teacher. If it hadn't been for this training, I think, I would have had a limited point of view and it would have remained the same. (Emrah)

There were differences between males and females in terms of the view of creativity. The male prospective teachers were defined creative thinking as a multi-dimensional thinking, while female prospective teacher defined as a product. Both of the gender groups regarded creativity as a mental activity, and below were some of the opinions they gave:

Then I saw every creative problem solving technique, I found out different ways of solution of a problem (Ferhat)

After the training, I believe this kind of activities improves mental skills." (Seydi)

### **Sub-theme 2 Thinking in Problem Solving**

Second sub-theme of thinking in problem solving was divided into the categories as divergent, reflective, and creative thinking. These thinking in problem solving ideas were outlined below.

#### **Sub-theme 2.1 Divergent Thinking**

Some opinions about prospective teachers' divergent thinking were given below:

I learnt to see things from a wider perception rather than a constant perception and that the thinking has improved." (Duygu)

I learnt to be able to see things from a different dimension. I believed people can

understand different things from the same things. I learnt new questions and ways of solution. (Nazmi)

We learnt different thinking techniques in this course. This enabled us to see an event from different dimensions. (Güven)

### **Sub-theme 2.2 Reflective Thinking**

Some opinions about prospective teachers' reflective thinking were given below:

Creativity education was enjoyable. However, as long as we can't use all of them to find solutions to the problems, we face in our daily of lives; the training in which we got these techniques can't be very useful." (Derya)

At the end of the process, the prospective teachers formed reflective concept patterns to their experiences, and their problem solving experiences.

### **Sub-theme 2.3 Creative Thinking**

The prospective teacher's opinions on creative thinking were as follows;

When the limits of my imagination were forced, I saw that really striking points start to appear. (Muhammed)

At the end of the course, I felt my brain was exhausted. But still with this exhaustion, I enjoyed to see what I can do." (Ahmet)

At the end of the training, I broke the fixed patterns of questions with fixed patterns. I am freer while thinking. For every matter or issue I come across, I started to seek the part of the icebergs in the sea. I stared at seeking something underlying the real thing. (Yellim)

The prospective teachers improved their creative thinking to solve challenging questions, situations needing strategy, fundamental knowledge and thinking groups, process of attitude and motives. They improved their potential for creative thinking in problem solving and creative thinking.

## **Sub-theme 3 Barriers to Creativity in Problem Solving**

A barrier to Creativity in Problem Solving was divided into the categories as fixation-inflexibility, educational system, incompetencies & in-capacities, difficulties, and habit sub-themes; they were presented with the support of prospective teachers opinions.

### **Sub-theme 3.1 Fixation-Inflexibility**

Prospective teachers indicated that they experienced fixation in problem solving, and, at the same time, inflexibility in their general outlook in life. They expressed these problems as follows:

Before, I would apply the problem solving techniques according to the question type. When I wanted to use certain techniques, I had difficulty..." (Canan).

I used to apply the techniques which arise in my mind first as I didn't have any idea of these creativity methods..." (Güven).

For example, while solving a geometry question, I used to try applying conventional methods to find the solution..." (Selma)

The prospective teachers' general views were, thanks to the training. They got over the entire fixation and restricted thinking.

### **Sub-theme 3.2 Habits**

Some of the prospective teachers' opinions were given below:

As people tend to keep the things which they were used to same, I also had a tendency to save my habits same at first... (Özhan).  
Removing the habits at once is very difficult. (Levent)

The prospective teachers stated that their habits prevented their ability to apply creativity and creativity in problem solving.

### Sub-theme 3.3 Difficulties

Some of prospective teachers suggested that the use of creativity techniques in schools would be difficult, and that this would affect problem solving.

I think those techniques will be difficult to apply in practice. (Seydi Vakkas)

It will be enjoyable for students but it will be difficult for teachers. Time would be a big problem. (Fatma)

The prospective teachers' stated that it is not possible to use teachers' creative techniques in problem solving because of the lack of information, time and equipment.

### Sub-theme 3.4 Incompetence's- Absence

The prospective teachers' opinion was given below:

Before the training, I did not know how these techniques will improve my creativity and the techniques to be helpful in my improvement and teaching. (Emine).

Below were some opinions about the prospective teachers' absence, not being prepared, and not being used to educational trainings:

It tired us a lot. We could not be motivated well, as we did not know if we could apply them or not. (Kadir).

Furthermore, it cannot be regarded as an educational period. I went through with pleasure since I was not used to such a narration. (Kadir).

During the training, some prospective teachers stated that they had lack of information about creativity and its techniques. This would effect their motivation and readiness.

### Sub-theme 3.5 Educational System

Their views were as follows

In fact, very positive outputs can be obtained, but as in our system based on two important examinations, that's why, I do not think sufficient time can be given for such activities (Veli)

If we applied them at primary and secondary school, this will not foster positive outputs. Because there are no teacher who can apply these techniques efficiently. The other point is that teachers and students were not ready to use these kinds of activities. (Kadir).

Except for that, I cannot agree that teachers, students and schools are capable of coping with such an innovative system (Emre).

Before the training, I had never come across such applications in educational system." (Güven)

The educational system, and the perceptions were real barriers for improving creativity in problem solving.

## Sub-theme 4 Improving Creativity in Problem Solving

Improving creativity in problem solving theme has four sub-themes; method of instruction, relating to daily life, permanence, and application, and they have been supported through the views of prospective teachers.

### Sub-theme 4.1 Method of Instruction

Prospective mathematics teachers consider all creativity techniques as a method of instruction. Below were some views:

I assume that the use of these techniques will provide the students with permanent and meaningful learning. Giving students responsibilities it will enable them to live and learn. (Duygu).

In this creativity training we have learnt learning and teaching... (Ömer)

With the training applied to mathematics education, as students will try to understand the problem, their learning through memorization will be removed... (Emine)

The prospective teachers consider each of the creativity techniques as a method of instruction to be realized and expressed that, they would reach efficient, permanent and meaningful learning. They emphasized the individualization of learning and enriching the educational climate with the help of these techniques.

### Sub-theme 4.2 Relating to Daily Life

Their views were as follows:

They can prepare students for life. They can relate to daily life." (Ferhat)

I believe these will enable educating students who learn better researches instead of memorizing, related to the subjects in real life." (Osman)

They suggest using open ended questions are related to daily life in order to improve creativity in problem solving.

### Sub-theme 4.3 Permanence in Creativity Education

The prospective teachers emphasized that creativity education should start at an early age to become permanent. Their viewpoints were given below.

The starting of divergent thinking of students can be prompted at a very early age. Thus, they will not have difficulty in future. (Emre). We should give that type of education at first grade of primary schools to university. (Prospective teacher Derya).

The prospective teachers drew attention to the starting of permanence education might be in an early age.

### Sub-theme 4.4 Application

I think it will be very practical if we use that at schools in mathematics education. They can be used to do different types of activities. Using it all the time decrease the productivity. (Gonca).

Thanks to the training, we understand the importance of creativity in education better. With it, positive opinions about creativity have increased. We learnt the techniques and methods we should use. We understand it was indispensable in education. (Ömer).

During the training, they regarded themselves as active, and confirmed the application of the learning training in mathematics trainings.

## CONCLUSIONS & DISCUSSION

This study try to find to draw the attention of prospective mathematics teachers' views on problem solving techniques in particular creative problem solving techniques in teacher training. At the end of the study creativity in problem solving divided into four themes as *individual characteristics in problem solving*; *thinking in problem solving*; *barriers to creativity in problem solving*; and *improving creativity in problem solving*. Each theme effected trainees' creative problem solving. The most important findings are developed positive attitude towards mathematics; trainees' open mindedness; to use different ways in problem solving. This kind of trainings has a great influence on an trainee's divergent thinking capacity. This study also reached some negative affects for example prejudices, negative attitude to learning new ideas, obsessions; mental, comprehensive, and emotional barriers. The fact that some prospective teachers faced fixation problems in problem solving is the end result of a memorizing form of education given by teachers who were not open to novelty. The continuation of this into university education made apparent the deficiencies of university education.

The mathematics teacher, who first of all, will use creativity in mathematics, should develop positive attitudes towards the training being applied. This will help to ease the application of the creativity techniques in the classroom. If the teacher can internalize the philosophy of training, the training will be successful. It was observed that the teachers, who approached the training with negative attitudes and prejudices, do not have open minds, and that they were closed off to learning new ideas. When some teachers' statements containing prejudices were analyzed, it was easy to perceive their mental barriers since they showed negative attitudes, and they clearly had perception barriers because of having a stereotype-

thinking pattern. Parnes (1978) put forth that prospective teachers indicated that by participating in the creativity training they developed their self-confidence and freedom. Scott et al. (2004) stated that the trainings aimed at developing creativity provided self-confidence to the participants.

Creativity trainings can be used for students to develop positive attitudes towards mathematics. There is a direct relation between attitudes and achievement (Ma & Kishor, 1997). Prospective mathematics teachers aim at teaching creative learning, and learning to think, and educating creative students were thought of as a goal that can be achieved through a complete student-centered approach.

Haylock (1987) determined that teachers who express their development of confidence and opinions to use different ways in problem solving, were an indicator of their getting rid of obsessions. On the other hand, there is a parallelism between teachers' using divergent and creative thinking together in mathematics lessons. Adding support to this was Haylock (1987) having an acceptance of teachers receiving improved creativity in problem solving by getting rid of obsessions, and through divergent thinking. Teachers who make statements supporting their ability to get rid themselves of obsessions were more suitable to Ediger's (2000) statement of a creative mathematics teacher.

From the fact that the female prospective teachers cannot relate divergent thinking and creativity we can reach the conclusion that they were not expected to show divergent thinking, and not motivated towards divergent thinking. One of the most important characteristics of the training is its effect on the divergent thinking of prospective teachers. Scott *et.al* (2004) confirmed that this kind of trainings has a great influence on an individual's divergent

thinking capacity. Mathematics teachers should be divergent, and Haylock (1987) accepted that this is an indicator of creativity as divergent thinking. Ediger (2000) indicated that divergent thinking, as a way to improve creativity in mathematics education, makes prospective mathematics teachers individuals who can think divergently.

Furthermore, in mathematics problems, one-way and divergent thinking should be combined together. According to Onda (1994), creative thinking can be accomplished only by the completion of these two thinking processes being combined together. In mathematics, open-ended and challenging questions can only be solved through the use of creative thinking (Kienel, 1977). Guilfor (1977) perceived creative thinking as the process of producing a new result by answering a new situation, and shows that he views creative thinking as another aspect of problem solving. The training had a developmental effect on prospective mathematics teachers' potential of creative thinking in problem solving for open-ended and challenging questions. Reflective thinking is in the focus of mathematics education. In addition, the goal of mathematics education is wide and efficient, yet at the same time rich and flexible, concept patterns (Meissner, 1999). From the statements made by the prospective teacher at the end of the training, we got the impression that the training was influential in bringing concept patterns up to a developable degree.

According to Sternberg (1996), the development of creativity is time-consuming, and it is quite normal that the techniques being applied take time to improve and understand. A prejudiced type of teacher prefers to judge rather than to generalize ideas, and have little or too much self-confidence stands as a barrier to the development of their creativity. It can be stated that those individuals could not overcome the mental, comprehensive, and

emotional barriers. Looking at these changes, we can say that some prospective teacher's barriers of stereotyped thinking, perception, and mentality, has been overcome, and that they reached necessary a mental openness for teachers who want to apply these techniques to accept students opinions, even if they were wrong, to see everyone is creative to a certain extent, and to encourage creativity.

The results reported here constitute our first report of a study. In this study, we observed that the prospective mathematics teachers accepted creative problem solving techniques. If the teacher does not know how to develop students' creativity and motivation, it is not possible to consider students' creative characteristics. That may be the reason for prospective teachers being stuck in fixation, permanence and application. In the course, trainees' selected techniques might be a factor on the prospective teachers' perceptions for the choice of the techniques being used in problem solving during teaching practice. This study seeks to draw the attention of prospective mathematics teachers' views on problem solving techniques in particular creative problem solving techniques in teacher training. If prospective teachers learn and use theories, teaching methods and techniques such as creativity techniques in pedagogical content course, they might be

using these techniques their teaching and learning. At the end of the 11 weeks training and analyzing the data in depth, they had overcome fixation, learnt challenging questioning, divergent thinking, how to teach and reflect, and the barriers to learning. In this way, this training is better than the classical mathematics education for mathematics teacher trainees. In sum, the creative training can really enhance creativity. Finally, prospective teachers believe that creativity can be learned and improved (Houtz, 2003) via activities of ongoing training and creative problem solving. The prospective teachers must have time and incentives in their educational trainings to permit and encourage the kinds of practice and reflections needed. Instructors have to find ways to permit prospective teachers to talk and discuss the current, and newly introduced topics. University mathematics education courses could meet partially this need. The methods courses should take responsibility for supporting the learning of pedagogical content knowledge including creative problem solving activities.

What is needed is improvement in the instruction and curriculum offered in all university mathematics education departments, and the courses that focus on the conceptual development of important topics in secondary mathematics.

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